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ABSTRACT

An investigation of how Mandarin-speaking children aged three to eight interpret sentences involving the universal quantifier "mei" ("every") and the quantificational adverbs "dou" ("all") and "quan" ("all") focused on how and when the child acquires adult interpretations of the quantifiers' scope. The subjects were 122 children in Beijing, and a control group of 20 adult university students and staff members. The instrument consisted of picture identification tasks, in which the children chose pictures to correspond to statements or manipulated toys with respect to empty boxes large enough to hold them. The results suggest that: (1) Mandarin-speaking children will have acquired universality of scope by age four, while their grasp of adult norms for scope relations does not come until after age eight, and acquisition of totality of scope precedes that of scope relations; (2) the young child does not show bias in interpreting sentences whose scope relations are understood with a clear bias for adults; (3) the ability to handle scope relations is contingent on the ability to recognize certain noun phrases and adverbs and is quantificational in nature; and (4) young children employ a unitary mechanism for comprehending scope relations, so sentences involving two universal and existential quantificational expressions will be understood in essentially the same way. (MSE)

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Acquisition of Quantificational Scope in Mandarin Chinese*

presented at the 18th Stanford
Child Language Research Forum
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Introduction

In the theory of Government and Binding, a rule of Quantifier Raising(QR) has been proposed to map from S-structure to Logical Form, adjoining noun phrases containing universal and existential quantifiers to a S node (May 1977). With free application of QR, a sentence such as 1 will have two well-formed Logical Form representations, as in 2 and 3.

1. [Every child] is eating [a cake]

2. [[Every child]$_i$ [[a cake]$_j$ [x_i is eating x_j]$_S$]$_S$]$_S$

3. [[A cake]$_j$ [[every child]$_i$ [x_i is eating x_j]$_S$]$_S$]$_S$

In 2, the quantificational noun phrase (Q-NP) every child has wide scope over a cake, so that the sentence could mean the children are eating different cakes. In 3, however, every child has narrow scope and the interpretation must be one where the children are sharing the same cake. The scope relations in the two sentences are given informally in 2a and 3a.

2a. For every x, x=child, there exists a y, y=cake, such that x is eating y

3a. There exists a y, y=cake, such that for every x, x=child, x is eating y

From an ontogenetic point of view, QR is of special interest because unlike syntactic movement rules relating Deep Structure and S-structure, the rule of QR does not involve overt movement, and the child therefore does not have positive evidence for postulating it. QR, in other words, is unlearnable and must be a rule of Universal Grammar (Hyams 1984). If this hypothesis is correct, it may be conjectured that children at very early years will have QR in their grammars, and that once they are able to identify certain NP's as quantificational NP's, they would apply QR freely to arrive at different well-formed LF representations. This implies that the early syntactic behavior of children should not show any bias in terms of interpretation of quantificational scope: with sentences such as 1, both wide and narrow scope interpretations should be possible in early child language.

The proposal that QR is a property of the initial state is of added interest because this is by no means an obvious assumption. Alternative hypotheses are equally plausible: one might propose, for instance, that the young child assumes some kind of

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isomorphism between SS and LF, so that the quantificational NP enjoying a more salient position, either linearly or hierachically, will have wide scope over another Q-NP occupying a less salient position (c.f. e.g. S.F.Huang 1981, J. Huang 1982:220). Empirical findings on the LF component of syntactic development will not only unravel language-specific facts, but could also stimulate discussion on theoretical formulations.

The Problem

The present study examines how Mandarin-speaking children between three and eight years of age interpret sentences involving the universal quantifier mei 'every' and the quantificational adverbs dou 'all' and quan 'all', as given in 4-7 below.

4. [xiongmao] dou shuijiao le
   panda all sleep asp./part.
   "The pandas have all fallen asleep" asp.=aspect
   part.=sentence

5. [mei ge xiongmao] dou shui le. final particle
   every CL panda all sleep asp./part. CL=classifier
   "Every panda has falled asleep"

6. [Qizi] quan fang zai [yige pingzi] li
   chesspiece all put at one-CL bottle in
   "Put all the chesspieces in a bottle"

7. [meige xiaomao] dou zuo zai [yige hezi] li
   every-CL kitten all sit at one-CL box in
   "Every kitten sits in a box"

The adverb dou must occur in preverbal position following subject/topic noun phrases in a clause, and quantifies all NP's preceding it (Li & Thompson 1981:336). Thus in 4, dou quantifies the subject NP xiongmao 'panda' and the entirety of the set of pandas referred to is predicated upon. It is possible to use dou in conjunction with the universal quantifier mei 'every', as can be seen from 5, which is essentially synonymous with 4.[5]

While 4 and 5 both contain only one quantifiable argument, 6 and 7 each consists of two quantifiable NP's.[6] The scope interpretations of 6 and 7 are in general quite clear: 6 means that all the chesspieces are to be placed in the same bottle, with yige pingzi 'a bottle' having wide scope; the normal interpretation of 7, on the other hand, is for the subject NP meige xiaomao "every kitten" to have wide scope over yige hezi "a box".[7]

In adult Chinese grammar, then, there are sentences such as 4 and 5, where the child needs to correctly assign universality of scope to the NP's preceding quantificational adverbs like dou. There are also sentences such as 6 and 7, where the scope relations of quantifiable NP's are determined not necessarily in a way corresponding to linear order or c-command relations. How and when does the Mandarin-speaking child acquire these adult

interpretations? By what age is the relevant acquisition process complete? What relationship, if any, exists between the acquisition of universality of scope (as in 4 and 5) and that of scope relations (as in 6 and 7)? Is the acquisition of quantification an abrupt process or a gradual one? Does the child in the early stages start with a unitary, undifferentiated mechanism for handling quantificational scope, or does he start tuning it to various adult interpretations of scope fairly early? These are the issues addressed in the present investigation.

Method

122 Mandarin-speaking children aged between three and eight years old were studied in Beijing, China. The subjects aged six and under were drawn from two nurseries, while the seven and eight year-olds came from a primary school. With the exception of the eight-year-old group, which consisted of only 13 children, each age was represented by 20 to 24 subjects. Due to the relative small sample size, no attempt was made to control for sex, though as far as possible an equal number of male and female children were sought. In addition, a total of 20 university students and staff aged between 19 and 36 years old were interviewed and asked to complete a questionnaire based on some of the test items administered to the children subjects. Table 1 gives details of the age and sex distribution among the subjects.

Table 1. Age and Number of Mandarin-speaking subjects

Age	Number of Subjects		Sub-total
	Male	Female	
3 year-olds	10	10	20
4 year-olds	15	7	22
5 year-olds	12	8	20
6 year-olds	12	12	24
7 year-olds	13	10	23
8 year-olds	5	8	13
		Total =	122
Adults	20	0	20

Test Items

The experiment comprised 20 picture identification tasks (three of which were training tasks) and 11 toy manipulation tasks. Some of these items did not bear directly on quantification and were concerned with other aspects of Chinese syntax.[3] Each child was seen by the same two experimenters, one of whom was the author, for an average of 15 to 25 minutes. The items immediately relevant to our discussion on quantification can be divided into two types, as shown below.

(Type I):

Type I items explore the child's understanding of the quantificational adverbs dou 'all' and quan 'all' as well as the universal quantifier mei 'every' when used in conjunction with dou.[4]

DOU1

[xiaogou] dou zuo xia lai le
doggie all sit down asp./part.
"The doggies have all sat down"

DOU2

[xiongmao] dou shuijiao le
panda all sleep asp/part.
"The pandas have all fallen asleep"

QUAN (same test picture as DOU2)

[xiongmao] quan shui le
panda all sleep asp./part.
"The pandas have all fallen asleep"

PMEDO1

[meike tang] dou na chu-lai
every-CL candy all take out
"Take every candy out"

PMEDO2

[meige tanqiu] dou na chu-lai
every-CL marble all take out
"Take every marble out"

DOU1, DOU2, and QUAN were comprehension tasks in which the child was asked to select from two pictures the one that corresponded to the sentence said by the experimenter. PMEDO1, PMEDO2 were production tasks in which the child was presented with a set of six candies or marbles and was asked to perform actions according

to the test sentences (Please refer to the Appendix for samples of test pictures and illustrations of toy props).

(Type II):

Type II items form the focal part of the test battery, as they examine the child's interpretation of the scope relations of two quantifiable NP's. MEYI1, MEYI2 were comprehension tasks in which the child had to make a choice out of three pictures. PMEYI1A, PMEYI2A, PMEYICEA, and PQUAN, PQUANC required manipulation of four toy objects with respect to four empty boxes large enough to hold the entire set of objects(see Appendix for pictures of these props).

MEYI1

[meige xiaopengyou] dou zai chi [yige dangao]
every-CL child all asp. eat one-CL cake
"Every child is eating a cake"

MEYI2

[meige xiaopengyou] dou zai he [yibei shui]
every-CL child all at drink one-CL water
"Every child is drinking a glass of water"

PMEYI1A

[meige xiaomao] dou zuo zai [yige hezi] li
every-CL kitten all sit at one-CL box in
"Every kitten sits in a box"

PMEYI2A

[meige jiqi/taikong-ren] dou shui zai [yige hezi] li
every-CL machine/spaceman all sleep at one-CL box in
"Every spaceman sleeps in a box"

PMEYICEA

[meike tang] dou fang zai [yige hezi] li
every-CL candy all put at one-CL box in
"Put every candy in a box"

PQUAN

[xiaomao] quan fang zai [yige hezi] li
kitten all put at one-CL box in
"Put all the kittens in a box"

PQUANC

[qizi] quan fang zai [yige hezi] li
chesspiece all put at one-CL box in
"Put all the chesspieces in a box"

The design of the above production tasks was based on one assumption: for tasks such as these, where clearly the spatial arrangement of the toys is likely to affect the child's performance, a more reliable indication of acquisition of adult norms can be obtained if the spatial arrangement of toys does not facilitate the adult reading. Thus, in both PMEYI1A and PMEYI2A, where the adult normally assigns wide scope to the subject NP, the boxes were stacked together in one pile rather than laid out separately. On the other hand, in the prop arrangement of PQUAN, PQUANC, which require a narrow scope reading of the subject NP, the boxes were placed in two terraced stacks, each box in clear view of the child. To examine possible configuration effects on the child, PMEYICFA --a task similar to PMEYI1A/2A but with a configuration facilitating a wide-scope reading -- was included.

The sequence in which the above test items were presented is given below. As can be seen from Table 2, the battery consisted essentially of a core of two parallel subtests, each more or less a mirror image of the other in terms of sequential order. It may also be observed that the above test items were by and large separated by other items which did not show an obvious relationship to quantificational scope.

Table 2. Sequence of Presentation of Test Items
(* indicates an intervening test item)

DOU1 **** > MEYI1 * > PQUAN * > PMEDO1 > PMEYI1A **

> PMEYI2A * > PMEDO2 > MEYI2 *** > DOU2 * > PMEYICFA *

> QUAN > PQUANC

Results
1. (Type I items)

Tables 3, 4 and 5 summarize the results of tasks requiring comprehension of mei, dou, quan. The data clearly show that the meaning of dou and quan as universal quantificational adverbs are acquired before four years of age.

Table 3. Acquisition of DOU in Mandarin
(Comprehension)

Age	No. of subjects correct on both subtests	No. of subjects correct on one subtest	No. of subjects incorrect on both subtests	Total
3 yr	11 (58 %)	5 (26 %)	3 (16 %)	19
4 yr	20 (91 %)	1 (4.5 %)	1 (4.5 %)	22
5 yr	20 (100 %)	0	0	20
6 yr	24 (100 %)	0	0	24
7 yr	23 (100 %)	0	0	23
8 yr	12 (92 %)	1 (8 %)	0	13

Table 4. Acquisition of GUAN in Mandarin
(Comprehension)

Age	Correct Responses	Incorrect Responses	Total
3 yr	15 (79%)	4 (21%)	19
4 yr	21 (95%)	1 (5%)	22
5 yr	20 (100%)	0	20
6 yr	24 (100%)	0	24
7 yr	23 (100%)	0	23
8 yr	13 (100%)	0	13

As regards the production tasks PMEDQ1/2, a similar pattern of responses can be observed, pointing to acquisition by four years old. It is worthy of note that as in other test items in the experiment, a higher degree of self-consistency is found in the production tasks than in the corresponding comprehension tasks, as Table 5 shows. The children of all age groups either responded correctly on both subtests or gave wrong responses for both subtests.

Table 5. Acquisition of MEI...DOU in Mandarin
(Production)

Age	No. of subjects correct on both subtests	No. of subjects correct on one subtest	No. of subjects incorrect on both subtests	Total
3 yr	12 (60 %)	0	8 (40 %)	20
4 yr	22 (100 %)	0	0	22
5 yr	20 (100 %)	0	0	20
6 yr	24 (100 %)	0	0	24
7 yr	23 (100 %)	0	0	23
8 yr	13 (100 %)	0	0	13

2. (Type II items)
(Acquisition of mei...yi)

With regard to Type II test sentences, the findings between comprehension and production tasks differ considerably. As is evident from Table 6, the data from MEYI1/2 do not show at first sight a pattern as clear as those in preceding tables. In general, the developmental path fluctuates and does not seem to follow a steady incline or decline.

Table 6. Acquisition of MEI.....YI in Mandarin
(Comprehension)

Age	Subjects with wide scope on both subtests	Subjects with wide scope on one subtest narrow scope on another	Subjects with narrow scope on both subtests	Subjects with at least one nonscope reading	Total
3 yr	4 (21%)	9 (47%)	1 (5%)	5 (26%)	19
4 yr	2 (9%)	10 (45%)	9 (41%)	1 (6%)	22
5 yr	3 (15%)	3 (15%)	14 (70%)	0	20
6 yr	3 (12.5%)	9 (38%)	12 (50%)	0	24
7 yr	8 (35%)	3 (13%)	12 (52%)	0	23
8 yr	3 (23%)	6 (46%)	4 (31%)	0	13
Adult	16 (80%)	4 (20%)	0	0	20

Despite the apparent irregularity (which may reflect the limitations of picture identification tasks for tapping this type of syntactic competence), some revealing tendencies can still be observed. One is that the number of consistent narrow-scope responses increases among the three and four-year-olds, followed by a gradual decline after five. Another tendency that should be noted is that non-scope responses (i.e. a choice that corresponds to neither a narrow or wide scope reading, cf. bottom picture of MEYI1 in Appendix) figure predominantly in the three-year-olds, and are almost completely absent from the older age groups.

In order to find out about the degree of self-consistency among subjects for these two comprehension tasks, a crosstab of MEYI1 and MEYI2 was carried out for all six age groups. It was found that the Chi-square values were significant for the four, six and seven year-olds ($p < 0.05$). If our attention is focussed only on these three groups, we can perceive in Table 6 a clear increase in consistent wide-scope readings (from 9% to 12.5% to 35%), such increase underlying an overall upward trend as reflected by the figures in the first column of Table 6.

When we turn to the corresponding production tasks PMEYI1A/2A, the above-mentioned tendencies are even more clearly manifested, as can be seen from Table 7 below.

Table 7. Acquisition of MEI...YI in Mandarin
(Production)

Age	Subjects with wide scope on both subtests	Subjects with wide scope on one subtest, narrow scope on another	Subjects with narrow scope on both subtests	Subjects with at least one nonscope reading	Total
3 yr	5 (25%)	1	9 (45 %)	5 (25%)	20
4 yr	7 (32%)	0	15 (68%)	0	22
5 yr	6 (30%)	1	13 (65%)	0	20
6 yr	11 (46%)	4	9 (38%)	0	24
7 yr	11 (48%)	3	9 (39%)	0	23
8 yr	8 (62%)	1	4 (31%)	0	13
Adult	19 (95%)		1 (5%)		20

(Note: adult subjects did only one subtest)

First, it should be mentioned that the subjects showed a very high degree of self-consistency in these two tests. A crosstab of the test results for these two production tasks yielded signficant Chi-square values for all six age groups ($p < 0.02$). The statistics in Table 7 confirm earlier observations on Table 6: a general increase of wide-scope readings with age (from 25% at three to 62% at eight), a virtual absence of non-scope readings after three, and a gradual decline of consistent narrow-scope readings after reaching a peak at around four or five. The data also reveal that the ability to handle scope relations presupposes an ability to interpret quantifiers. Of the five subjects showing non-scope responses in PMEYI1A/2A, all of them consistently responded in this fashion oh both subtests, and without exception they all failed the PMEDO1/PMEDO2 tests.

The findings from the configuration control item PMEYICFA show a similar trend, except that the percentages for wide-scope readings are higher, apparently due to the facilitating effect of the configuration of toy props.

Table 8. Acquisition of MEI...YI in Mandarin
(Production, with configuration control)

Age	No. of subjects with wide scope reading	No. of subjects with narrow scope reading	No. of subjects with nonscope reading	Total
3 yrold	6 (30%)	9 (45%)	5 (25%)	20
4 yrold	9 (41%)	12 (55%)	1 (4%)	22
5 yrold	8 (40%)	12 (60%)	0	20
6 yrold	17 (71%)	7 (29%)	0	24
7 yrold	18 (78%)	5 (22%)	0	23
8 yrold	9 (69%)	4 (31%)	0	13

The combined data point to a gradual evolution toward adult norms, which do not seem to be acquired until well after eight. The findings also reveal a sharp contrast between the early acquisition of the universality of scope (DOU1/2, PMEDO1/2) and the relatively gradual and late acquisition of quantificational scope (MEYI1/2, PMEYI1A/2A, PMEYICFA).

(Type II items)
(Acquisition of quan...yi)

The children's interpretation of the sentences in PQUAN, PQUANC, which require narrow scope readings of the subject NP according to adult norms, provides an interesting perspective on the child's grammar. It appears that the child in the early stages does not have a bias toward a narrow-scope reading. As Table 9 shows, half of the three-year-olds (please refer to the third and fourth columns in the table) did not give a narrow scope reading on either of the subtests. Beginning at four, however, the percentage of subjects giving consistent narrow-scope responses reached 50% and gradually increased to 70% by seven. One might attribute the lack of a narrow-scope bias to the effects of the PMEYI items, but this does not seem plausible, as in the experiment, the first production task involving scope relations was PQUAN (see Table 2 for details). The child's performance on the task in fact recorded his first interpretation of scope relations in a production item.

Table 9. Acquisition of QUAN.....YI in Mandarin
(Production)

Age	Subjects with narrow scope on both subtests	Subjects with narrow scope on one subtest wide scope on another	Subjects with wide scope on both subtests	Subjects with at least one nonscope reading	Tot
3 yr	8 (40%)	2	5 (25%)	5 (25%)	
4 yr	11 (50%)	4	6 (27%)	1	
5 yr	13 (65%)	3	4 (20%)	0	
6 yr	13 (54%)	5	6 (25%)	0	
7 yr	16 (70%)	3	4 (17%)	0	
8 yr	12 (92%)	1	0	0	

To observe the relationship between PQUAN/PQUANC on the one hand, and PMEYI1A/2A, PMEYICFA on the other, the results of the respective subtests were added so that a consistent correct response on both subtests will amount to a score of 2 points, a correct response on one of the subtests would count as 1 point, while the absence of any correct responses would be scored as 0. Thus a global PQUAN is compared to a global PMEYI as well as to PMEYICFA. Crosstab results indicate that PQUAN interacted

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significantly with MEIYI at four and five ($p < 0.002$), and with MEIYIGEA at three, four and five, as demonstrated by Table 10.

Table 10. CrossTab of MEI..YI tasks and QUAN...YI tasks

	MEIYI1A/MEIYI2A combined	MEIYIGEA
QUAN/QUANG combined	signficant for 4,5 year olds ($p<0.002$)	significant for 3 year olds($p<0.06$); significant for 4,5 year olds ($p<0.001$)

This suggests that the child under five has not acquired the adult distinctions in their interpretation of scope relations in sentences such as the following:

MEIYI2A

(meige jiqi/taikong-ren) dou shui zai (yige hezi) li
every-CL machine/space-man all sleep at one-CL box in
"Every spaceman sleeps in a box"

QUANG

(qizi) quan fang zai (yige pingzi) li
chesspiece all put at one-CL bottle in
"Put all the chesspieces in a bottle"

Instead, the children in their early years seem to use a single mechanism for handling scope relations in sentences involving two quantifiable noun phrases.

Conclusions

Based on the experimental findings on the child's understanding of Type I and Type II sentences, the following conclusions may be drawn:

1. Mandarin-speaking children will have acquired universality of scope by age four, while their grasp of adult norms for scope relations does not come until after eight. Acquisition of totality of scope precedes that of scope relations.

2. The young child does not show any bias in interpreting sentences whose scope relations are understood with a clear bias for adults. This confirms our hypothesis about the

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unlearnability of Quantifier Raising and its free application.

3. The fact that subjects giving non-scope readings in production tasks were precisely those who had not acquired universality of scope demonstrates that the ability to handle scope relations is contingent upon the ability to recognize certain noun phrases and adverbs as being quantificational in nature. In terms of QR, this means that if quantificational expressions are not recognized as such, then the condition for application of QR will not be met, and QR will not apply to yield well-formed LF representations.[4]

4. The child in his early years employs a unitary mechanism for comprehending scope relations, so that sentences involving two universal and existential quantificational expressions will be understood in essentially the same way.

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Notes

1. Sentence 4 can also mean "even the pandas have fallen asleep" while 5 cannot have this second reading because of the presence of mei. The "even" reading goes beyond the scope of the present study. Note that when mei is used, dou is obligatory, so that if dou is left out of 5, the sentence is unacceptable:

   *meige xiongmao shuijiao le
   every-CL panda sleep asp./part.
   "Every panda has fallen asleep"

2. Following May (1977), quantificational NP refers to noun phrases containing quantifiers such as every, some, a, all as determiners. The term quantifiable NP is used in this paper to refer to a noun phrase denoting a set of entities of cardinality more than one.

3. Note that the following sentence, where dou is used instead of quan, has the same meaning as 6:

   [qizi] dou fang zai [yige pingzi] li
   chesspiece all put at one-CL bottle in
   "Put all the chesspieces in a bottle"

4. These tasks relate to the child's grasp of topic structures and scope relations involving modals and negation.

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5. As pointed out in Note 1, the occurrence of mei is sanctioned by the presence of dou. Therefore, it is not possible to test the child's understanding of mei alone.

6. It was decided that the comprehension results of one of the three-year-olds should be rejected because of extremely low self-consistency, although her performance on production tasks was on the whole considered valid.

7. May's rule of QR deals only with quantificational NP's and the interface between SS and LF. Clearly, quantification of noun phrases not containing quantifier determiners by adverbs such as dou in post LF stages are also relevant to the child's acquisition of quantification.

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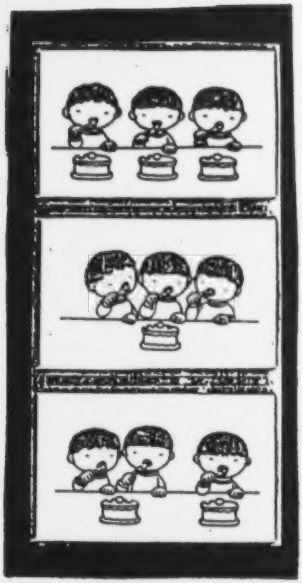
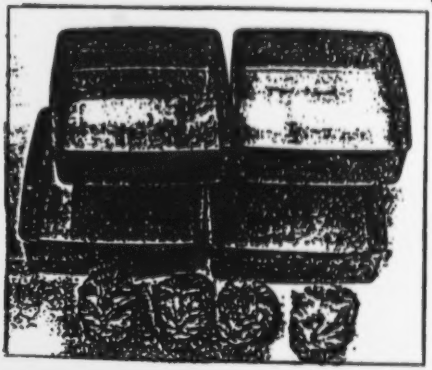
Appendix

Test Pictures and Arrangement of Toy Props



MEYI1

DOU2



POUAN

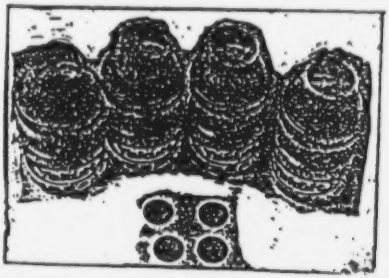
Appendix

Test Pictures and Arrangement of

Toy Props (cont'd)

PMEY11A

PMEYICFA



PQUANC

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